

FIG. 9

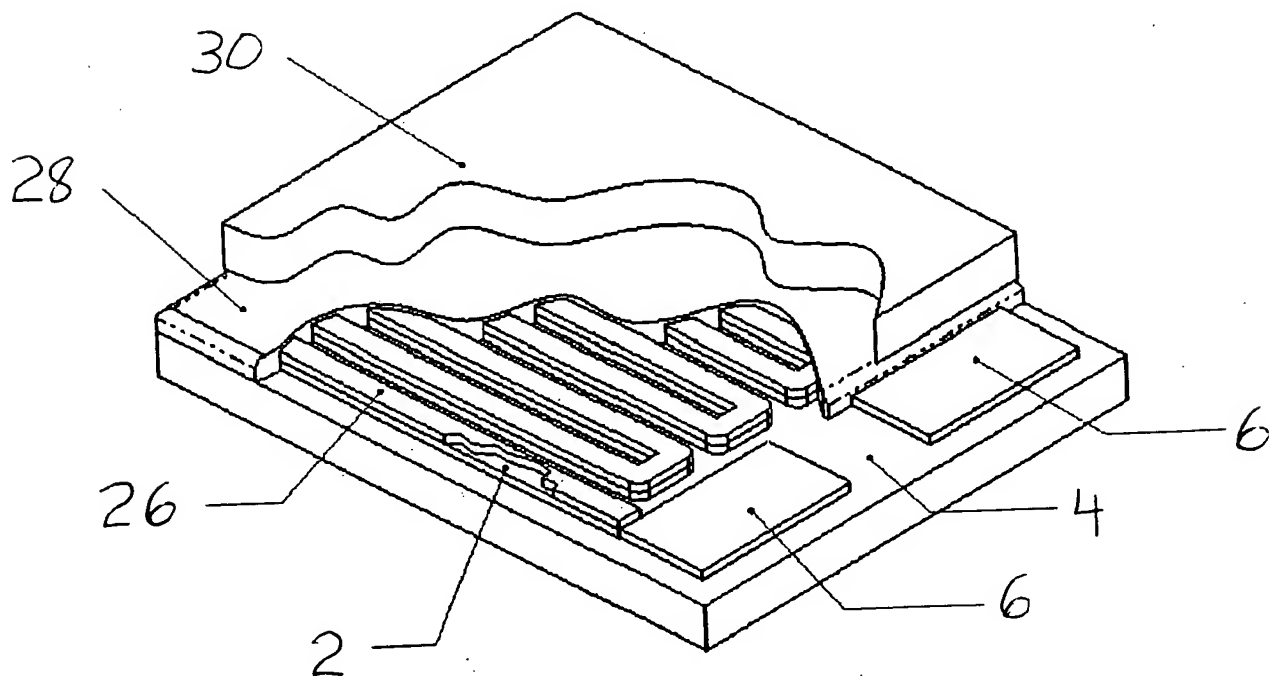
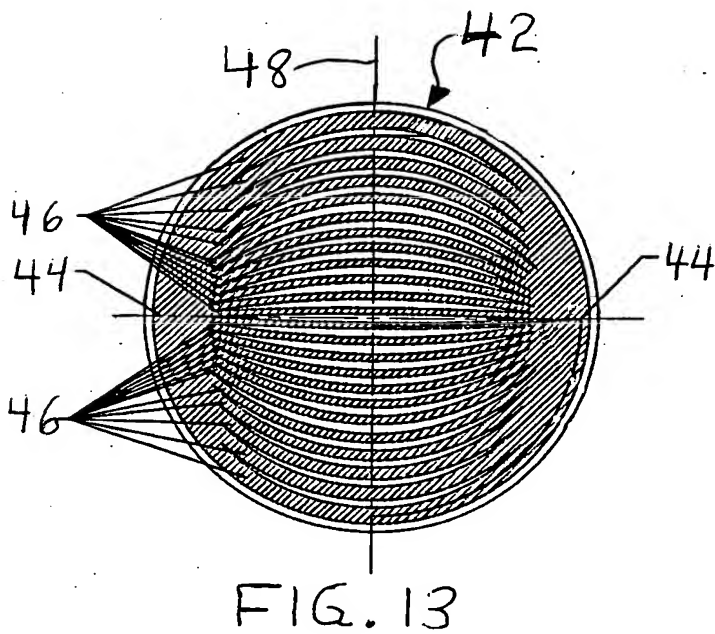
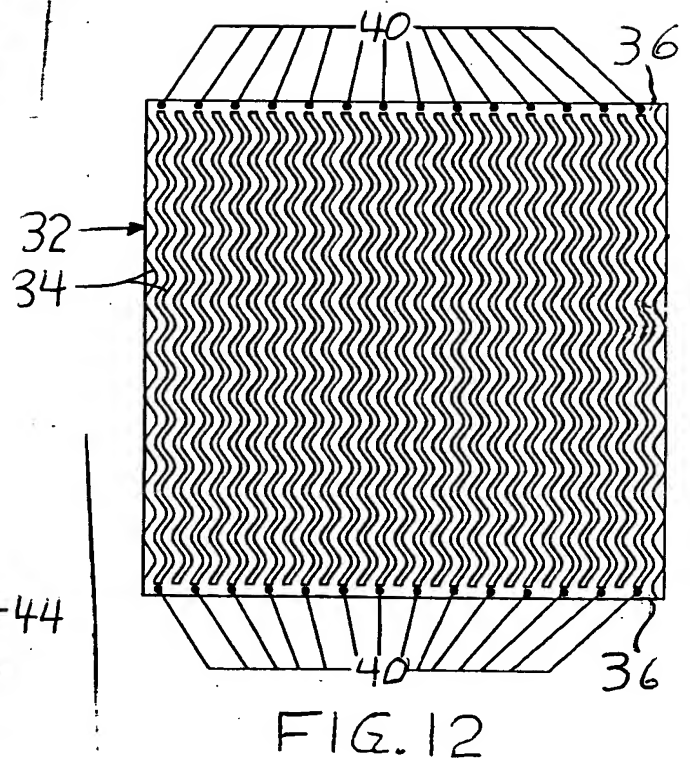
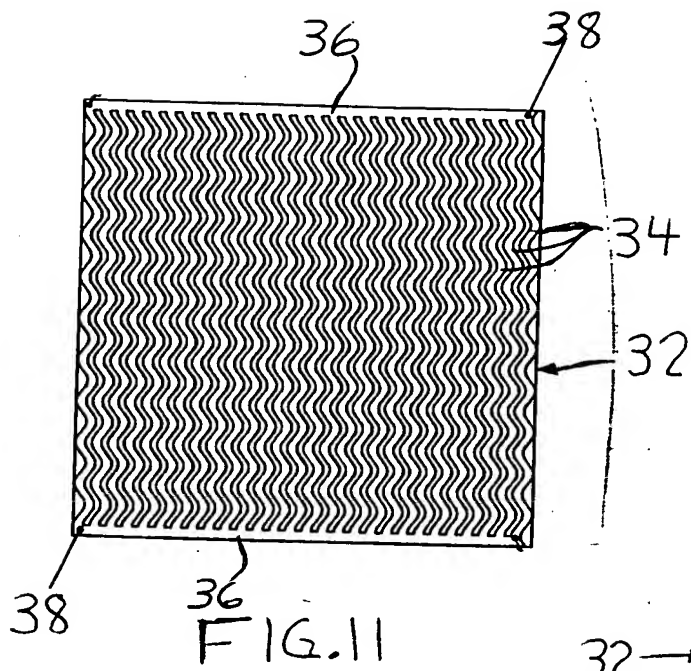


FIG. 10



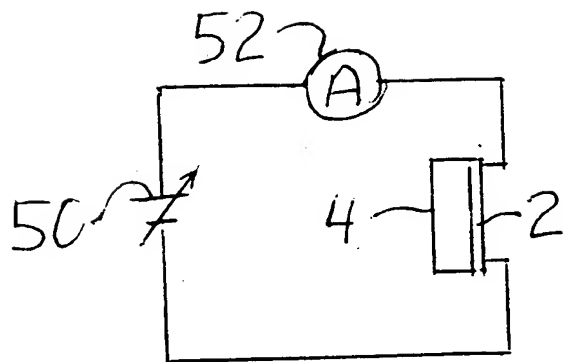


FIG. 14

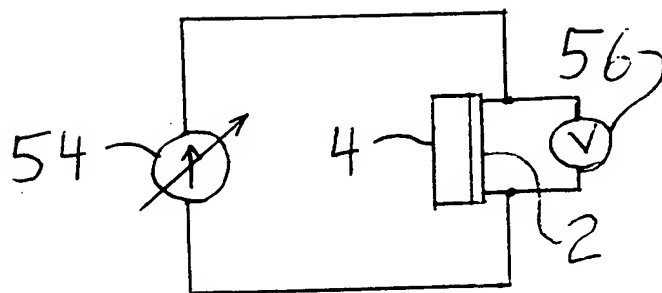


FIG. 15

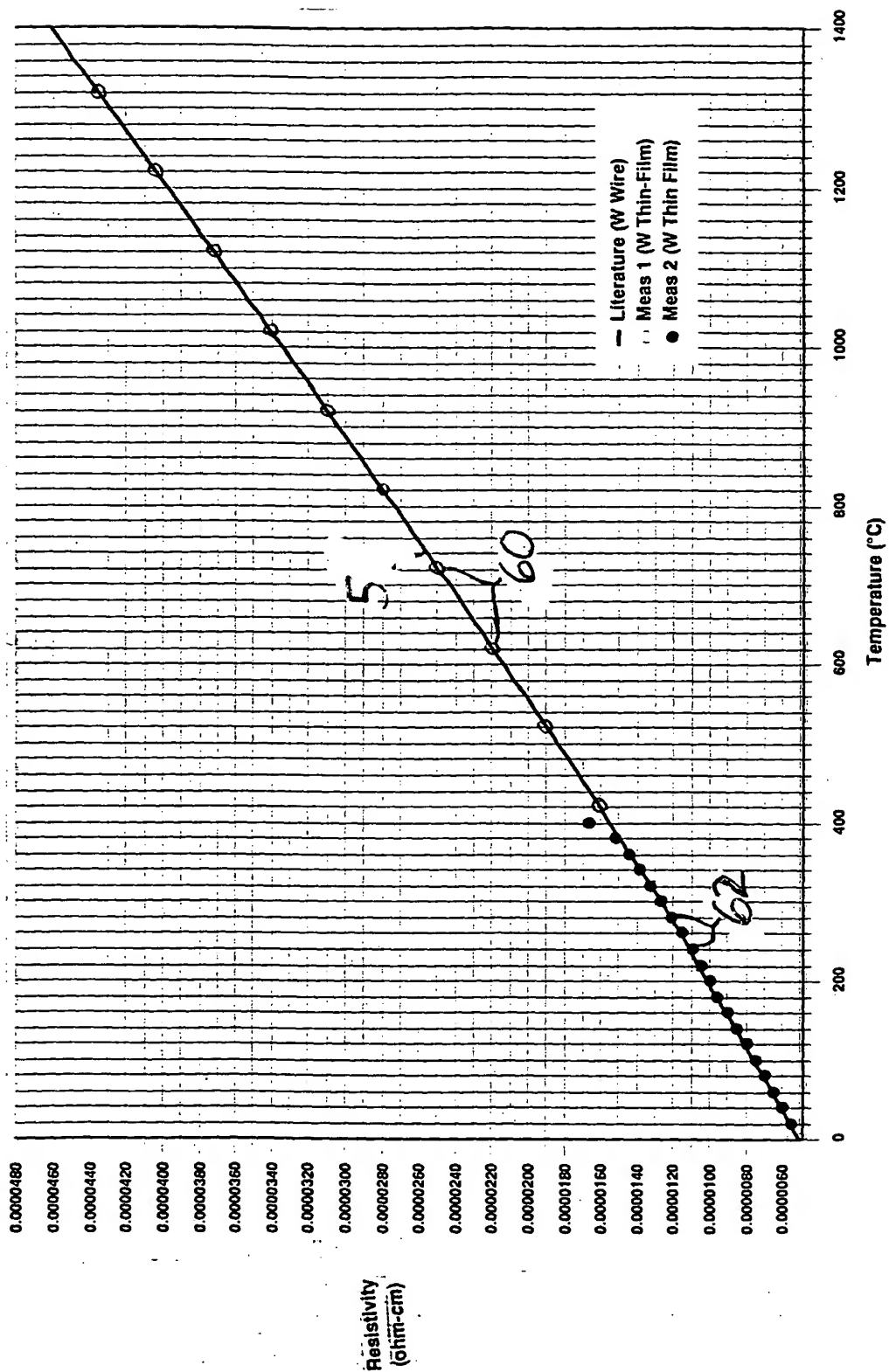


FIG. 16

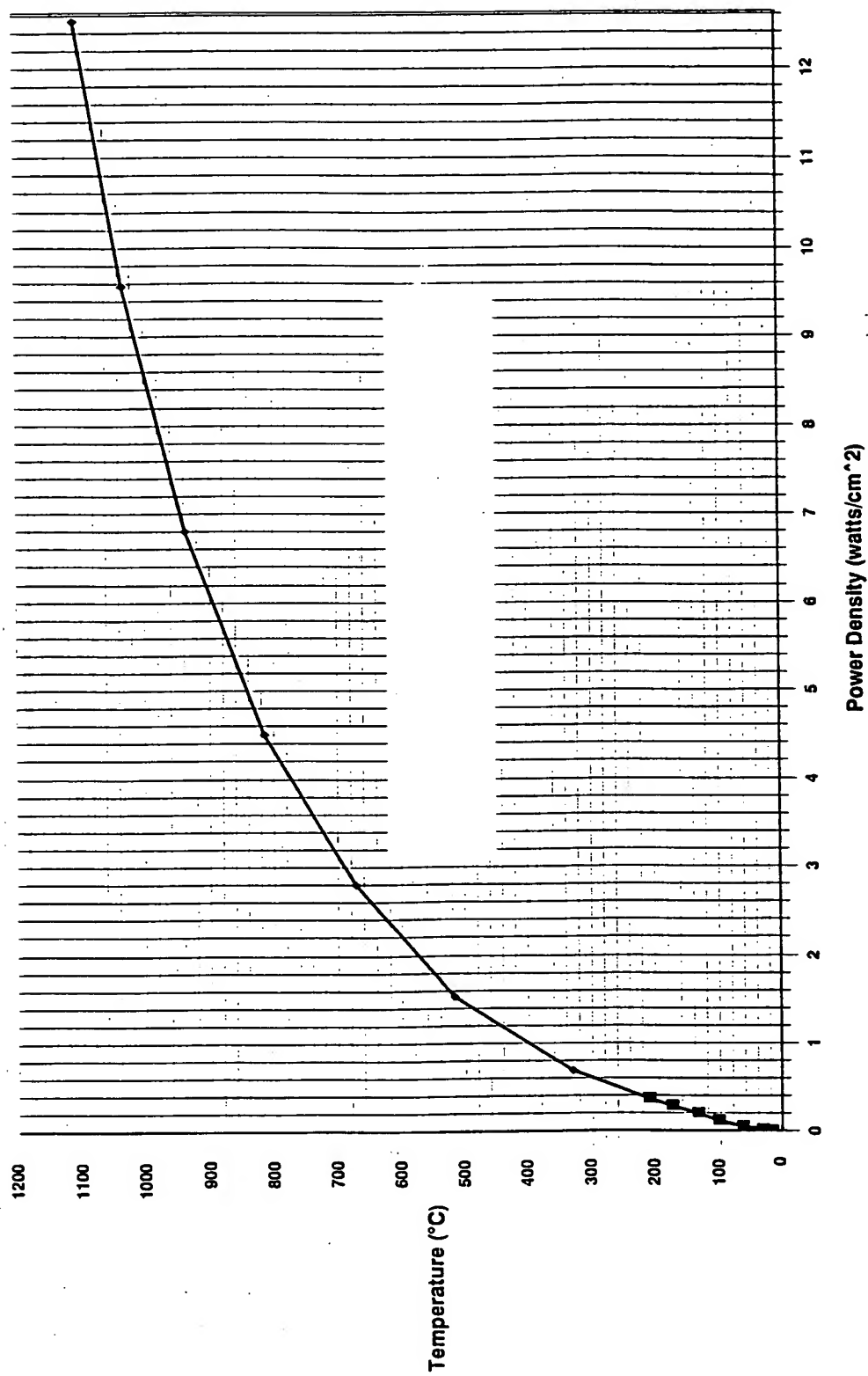


FIG. 17

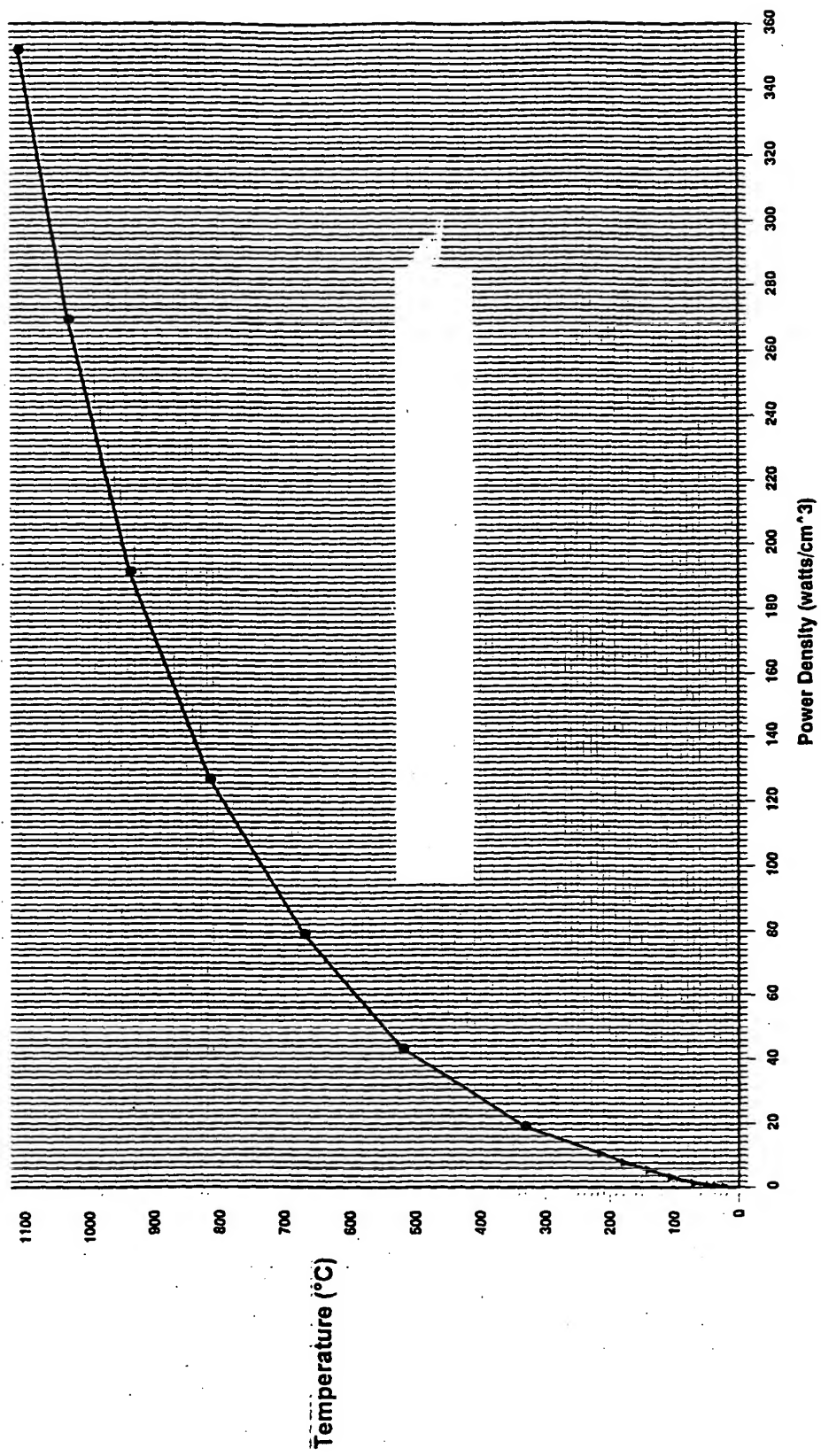
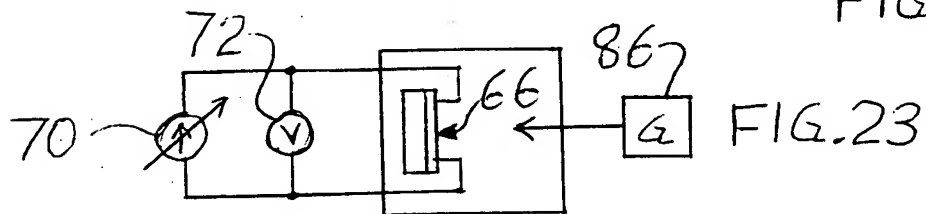
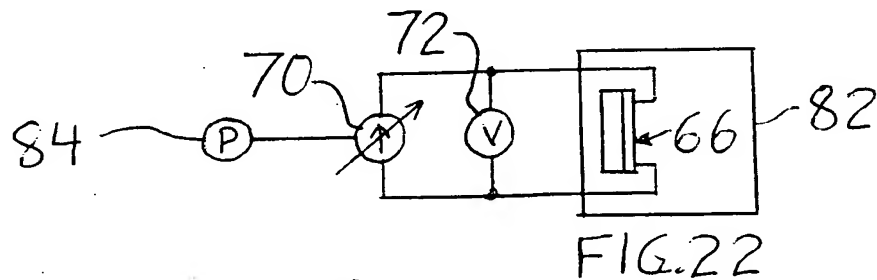
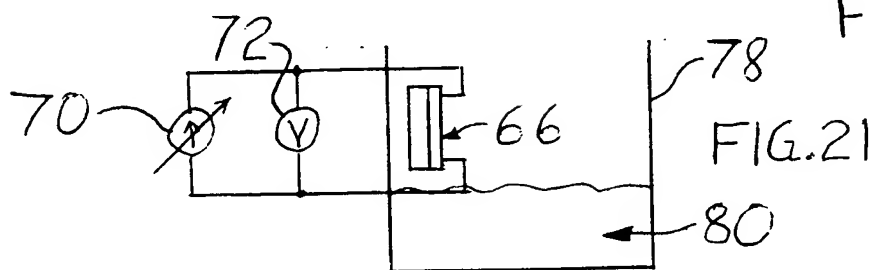
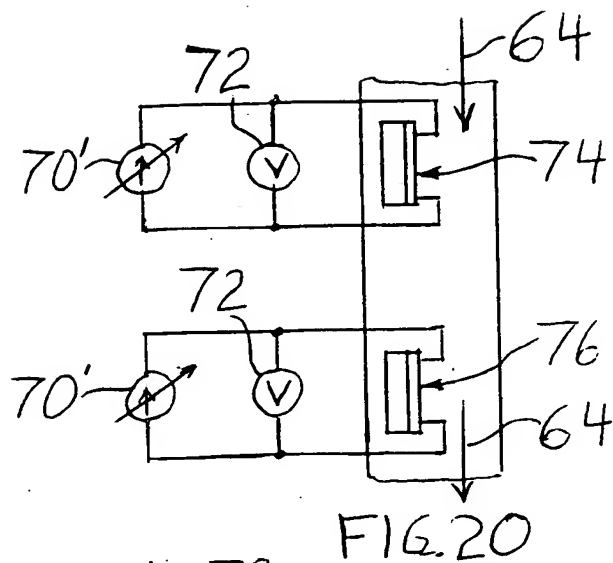
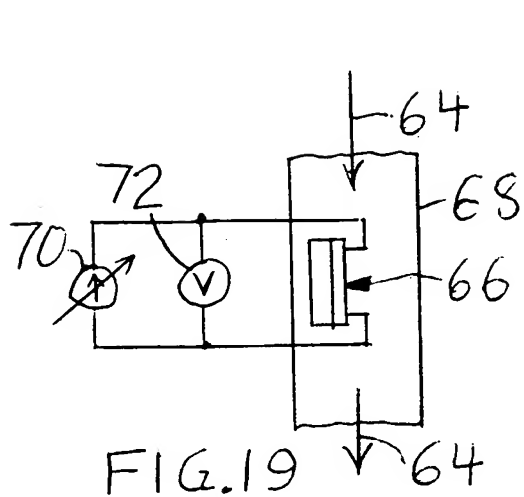


FIG. 18



TEMPERATURE RANGE (°C) FOR DIFFERENT OPERATING ENVIRONMENTS

FIG. #	Air/Oxygen	Ar, He or N ₂	H ₂	Vacuum
1	<-196 to ~260	<-196 to ~1800	<-196 to ~1800	<-196 to ~1800
2	<-196 to ~1250	<-196 to ~1800	<-196 to ~1800	<-196 to ~1800
3	<-196 to ~1000	<-196 to ~1000	<-196 to ~1000	<-196 to ~1000
4	<-20 to ~1250	<-20 to ~1300	Not Applicable	<-20 to ~1300
5	<-20 to ~1250	<-20 to ~1300	<-20 to ~1300	<-20 to ~1300
6	<-196 to ~1250	<-196 to ~1300	Not Applicable	Not Applicable
8	<-196 to ~1250	<-196 to ~1300	<-196 to ~1300	<-196 to ~1300
9	<-196 to ~1250	<-196 to ~1300	<-196 to ~1300	<-196 to ~1300
10	<-196 to ~1250	<-196 to ~1400	<-196 to ~1400	<-196 to ~1400

FIG. 24

TEMPERATURE SENSORS

Characteristic	Best Completed Structure FIG. # Result		Platinum Thin-Film RTD	Thermistor
	FIG. #	Result		
Max. Zero-Drift Temperature (°C) • Steady State • Thermal Cycling	1,2,4,5,6,8,9,10	>1200	~500	<0
	1,2,4,5,6,8,9,10	>1200	~400	<0
Internal Drift Mechanisms (Within Zero-Drift Temp. Range) • Grain-Growth • Densification: • Diffusion (Measurable): • Expansion Mismatch (α) • Substrate/Circuit • Electrode/Circuit	1,2,4,5,6,8,9,10	No	No	Yes
	1,2,4,5,6,8,9,10	No	No	Yes
	1,2,4,5,6,8,9,10	No	No	Yes
	1	≤0.06	~0.13	0
	1	~0	~0	>0.3
Maximum Temperature (°C) vs Environments • Unencapsulated: • Oxygen • Ar, He, N ₂ • Hydrogen • Vacuum • Encapsulated • Oxygen • Ar, He, N ₂ • Vacuum	2,4,5,6,8,9,10	~1250	~850	~300
	1,2	~1800	~850	~300
	1,2	~1800	Not Applicable	~300
	1,2	~1800	Not Applicable	<300
	1,2,10	~1400	~850	~300
	1,2,10	~1400	~850	~300
Precision Limit: (°C)	1,2	±0.0001	±0.001	±0.01
Resp nse Time (Ratio to Platinum Thin-Film RTD)	1,2,4,5,6,8,9,10	≤0.1	1	>2
Resp nse Type:	1,2,4,5,6,8,9,10	~Linear	~Linear	Exponential
Substrat Thermal Conductivity (W/cm/°K)	1-6,8-10	2.4	0.35	≤0.1
Maximum Temperature Range (°C)	1,2	<-195 to ~1800	<-195 to ~850	<0 to ~800

FIG. 25

HEATER STRUCTURES

Characteristics	Best Completed Structures		Bulk	Foil	Rods & Bars	Planar Heaters	Tungsten Wire
	FIG. #	Property					
Source Type	1-6, 8-10	Plane	Plane	Plane	Line	Plane	Line
Heating Modes							
• Contact	1-6, 8-10	Yes	Yes	No	No	Yes	No
• Radiative	1-6, 8-10	Yes	Yes	Yes	Yes	Yes	Yes
$\Delta T(^{\circ}\text{C})$ Heater-Object @2" (5cm)	1-6, 8-10	~100	~100	~100	~800	~100	>1500
Max. Temp. ($^{\circ}\text{C}$) vs Environment							
• Oxygen	3 (capped)	~1800	~1300	~1000	~1000	~700	~300
• Ar, He, N ₂	1, 2	~1800	~1300	~3000	~3000	~700	~3000
• Vacuum	1, 2	~1800	~1300	~3000	~3000	~700	~3000
• Hydrogen	1, 2	~1800	~1300	~3000	~3000	~700	~1800
Time to Max. Temp. ($^{\circ}\text{C}$), (Seconds)	1, 2, 4, 5, 6, 8, 9, 10						
• Heater	1, 2, 4, 5, 6, 8, 9, 10	<3	<60	<30	<60	<60	<3
• Object @2" (5cm)	1, 2, 4, 5, 6, 8, 9, 10	<4	<60	<120	<120	<90	<10
Radiative Heating Efficiency	1, 2, 4, 5, 6, 8, 9, 10	Excellent	Very Good	Very Good	Poor	Excellent	Poor
Substrate Thermal Conducting (W/cm/ $^{\circ}\text{K}$)	1-6, 8-10	2.4	2.4	~0.1	N/A	0.26-2.4	N/A

FIG. 26